REMARKS

Claims 2, 3, 5-16 and 18-28 remain herein.

The March 27, 2003 Office Action contains a request that Figures 10 and 11 be labeled "Prior Art." Attached is a Submission of Proposed Drawing Amendment for Approval by Examiner in which the applicants propose to label Figures 10 and 11 "Prior Art." Authorization to make these changes in the formal drawings is respectfully requested.

The March 27, 2003 Office Action also contains an objection to claims 9 and 13. In response, the claims have been amended as set forth above, including changes which address this objection. Reconsideration and withdrawal of this objection are requested.

Attached hereto as pages 41-44, pursuant to Rule 1.121(c)(1)(ii), is a marked-up version of the amended claims.

Claims 9-16, 21, 23, 25 and 27 were rejected under 35 U.S.C.§102(a) over European 1 059 681 (EP '681).

Attached hereto is a certified translation of Japanese 2000-094,233, from which the present application claims priority. Japanese 2000-094,233 was filed in Japan on March 30, 2000, i.e., prior to the date of publication of EP '681 (December 13, 2000). The subject matter of each of claims 9-16, 21, 23, 25 and 27 is supported by disclosure in JP 2000-094,233. Accordingly, the effective filing date for claims 9-16, 21, 23, 25 and 27 is prior to the date of publication of EP '681. Therefore, EP '681 is not prior art to those claims under 35 U.S.C. 102(a). Accordingly, reconsideration and withdrawal of this rejection are requested.

Claims 9-16, 21, 23, 25 and 27 were rejected under 35 U.S.C.§102(e) over U.S. Patent No. 6,468,692 (Nemoto '692).

As mentioned above, attached hereto is a certified translation of Japanese 2000-094,233, from which the present application claims priority. Japanese 2000-094,233 was filed in Japan on March 30, 2000, i.e., prior to the U.S. filing date of Nemoto '692 (May 26, 2000). The subject matter of each of claims 9-16, 21, 23, 25 and 27 is supported by disclosure in JP 2000-094,233. Accordingly, the effective filing date for claims 9-16, 21, 23, 25 and 27 is prior to the date of publication of Nemoto '692. Accordingly, Nemoto '692 is not prior art to those claims under 35 U.S.C. 102(e). Accordingly, reconsideration and withdrawal of this rejection are requested.

Claims 1-4, 6, 7, 18-20, 22, 24 and 26 were rejected under 35 U.S.C.§103(a) over Japanese 10-162801 (JP '801) in view of European 895 297 (EP '297).

JP '801 discloses a secondary battery comprising: a positive side collector foil (7a) having a positive active material (8a); a negative side collector foil (7b) having a negative active material (8b); gas permeable separator (12); and a hollow core (13). The separator (12) is sandwiched between the positive side collector foil (7a) and the negative side collector foil (7b) and they are wound around the hollow core (13), so as to constitute an electrode structure (10). Each positive side collector foil (7a) and the negative side collector foil (7b) has plural pores, and the hollow core has plural pores, thereby forming a gas channel for discharging gas generated in the electrode structure (10). JP '801 also discloses a valve (4) in a position corresponding with the center axis of the hollow core.

However, as acknowledged in the March 27, 2003 Office Action, JP '801 does not disclose the sectional area (S2) of the center hollow portion of the winding core, as recited in claims 6 and 19? 9, amended as set forth above. Accordingly, no combination of JP '801 and EP '297 would provide or render obvious the subject matter recited in claim 6 or in claim 9, from which claims 2, 3, 7, 18-20, 22, 24 and 26 each ultimately depend.

In addition, JP '801 is directed to prevention of deterioration of battery performance by discharging gas generated in the electrode structure (10) via gas channels in the diametrical direction of the battery. The gas described in JP '801 is generated during normal usage of a secondary battery. In addition, the secondary battery disclosed in JP '801 is not specifically directed to a lithium secondary battery. On the contrary, the present invention is directed to improving safety and productivity of a lithium secondary battery. The pressure release hole of the present invention is provided for avoiding bursting caused by abnormalities at the time of charging or discharging, by releasing gas in an axial direction of the battery. Accordingly, the purpose and the concept of the present invention are distinct from those of JP '801. A person of skill in the art who was attempting to improve the safety and productivity of the lithium secondary battery described in EP '297 would not look to disclosure in JP '801, which is directed merely to any kind of secondary battery during normal usage.

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Reconsideration and withdrawal of this rejection are requested.

Claims 5 and 8 were rejected under 35 U.S.C.§103(a) over JP '801 in view of EP '297,

further in view of U.S. Patent No. 5,571,632 (Teramoto '632). Teramoto '632 is relied on for alleged disclosure of an inner tube made of aluminum and having a thickness of 2 mm. Teramoto '632 discloses a secondary battery having a double tube structure. The inside of the inner tube of Teramoto '632 communicates with the external environment and therefore cannot provide the pressure release function of the present invention. Accordingly, Teramoto '632 does not provide any suggestion which would lead one of skill in the art to provide a hollow cylindrical winding core, which communicates with the interior of a secondary battery to have a specific thickness. The significance of the specific thickness of the winding core in accordance with the present invention is demonstrated by comparison of Examples 1-4 and Comparative Example 1 of the present specification.

Reconsideration and withdrawal of this rejection are requested.

Claim 28 was rejected under 35 U.S.C.§103(a) over EP '681.

As mentioned above, attached hereto is a certified translation of Japanese 2000-094,233, from which the present application claims priority. Japanese 2000-094,233 was filed in Japan on March 30, 2000, i.e., prior to the date of publication of EP '681 (December 13, 2000). The subject matter of claim 28 is supported by disclosure in JP 2000-094,233. Accordingly, the effective filing date for claim 28 is prior to the date of publication of EP '681. Accordingly, EP '681 is not prior art to claim 28 under 35 U.S.C. 102(a). Accordingly, reconsideration and withdrawal of this rejection are requested.

Claims 9 and 17 were rejected under U.S.C.§103(a) over JP '801 in view of EP '681.

Claim 17 is canceled, as set forth above. As mentioned above, attached hereto is a certified translation of Japanese 2000-094,233, from which the present application claims priority. Japanese 2000-094,233 was filed in Japan on March 30, 2000, i.e., prior to the date of publication of EP '681 (December 13, 2000). The subject matter of claim 9 is supported by disclosure in JP 2000-094,233. Accordingly, the effective filing date for claim 9 is prior to the date of publication of EP '681. Accordingly, EP '681 is not prior art to claim 9 under 35 U.S.C. 102(a). Accordingly, reconsideration and withdrawal of this rejection are requested.

Claims 9-16, 21, 23, 25 and 27 were rejected under obviousness-type double patenting over claims 1-23 of Nemoto '692.

Nemoto '692 does not disclose or suggest a lithium secondary battery which has a

pressure release hole in a position corresponding with the center axis of the winding core, as recited in claim 9, amended as set forth above. Claims 10-16, 21, 23, 25 and 27 all ultimately depend from claim 9. Reconsideration and withdrawal of this rejection are requested.

Claims 1-3, 18, 19, 22, 24 and 26 were provisionally rejected under obviousness-type double patenting over claims 1-53 of U.S. Application Serial No. 09/863,108 (the '108 application).

In view of the provisional nature of this rejection, the applicants would like to defer consideration of this rejection.

If the Examiner believes that contact with Applicant's attorney would be advantageous toward the disposition of this case, the Examiner is herein requested to call Applicant's attorney at the phone number noted below.

The Commissioner is hereby authorized to charge any additional fees associated with this communication or credit any overpayment to Deposit Account No. 50-1446.

Respectfully submitted,

June 27, 2003
Date

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Abstract of the Disclosure

a4

A lithium secondary battery has an internal electrode body formed by winding a positive electrode and a negative electrode on an outer peripheral wall of a hollow winding core and filled with nonaqueous electrolyte solution, a cylindrical battery case containing this internal electrode body 1 inside with its both ends being open, and electrode caps which each have a battery cap, an internal terminal, and an external terminal, the internal electrode body being sealed by the electrode caps at both open ends of the battery case. At least one of the electrode caps has a pressure release hole in a position corresponding with the center axis of the winding core.

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Please amend the paragraphs at page 1, line 21 – page 2, line 27, to read as follows:

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a7

This lithium secondary battery is advantageous in that it has high operating voltage and high energy density and can discharge a large current, but is inconvenient in that the rise of a battery temperature caused by abnormalities at the time of charging or discharging, for example, over-discharging due to a short circuit of external terminals, or over-charging due to malfunction of a charging device accompanies the rise of inner pressure resulting in a burst of the battery. Accordingly, the lithium secondary battery comprises a pressure release hole in an electrode cap being its component as a safety mechanism for preventing this burst, and on the inner periphery wall or at the end of the pressure release hole a pressure release valve is disposed. As shown in Fig. 10, conventionally this pressure release hole 18 is disposed in the vicinity of the outer periphery of the electrode cap apart from the central axis of the battery case 24.

However, the pressure release hole disposed in the vicinity of the outer periphery of the electrode cap must be disposed in both of the positive and the negative electrode caps, otherwise, insufficiency in releasing gasses from the center hollow portion of the winding core (which contains a lot of gases to cause inner pressure increase) makes it impossible to prevent the battery from bursting which used to be a problem. In addition, when a pressure release hole is disposed in the vicinity of the outer periphery of the electrode cap, electrolyte solution inlet must be disposed separately, and since the electrode cap requires two holes, the area of the portions to be sealed will become large, giving rise to aptness of leakage of the electrolyte solution, which used to be a problem.

Please amend the paragraph at page 3, lines 7 – 18, to read as follows:

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a8

In addition, conventionally, the pressure release valve is configured as shown in Fig. 11 by pressing an airtight ring 44 for fixing with a pressure fixing ring 43 where a hole 42 is provided in a battery case 41 (reference should be made to Japanese Patent Laid-Open No. 11-49217, etc.). However, Japanese Patent Laid-Open No. 11-49217 did not disclose any solving means such as particular shapes of components of the pressure

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a8 Contd.

release valve and the fixing pressure at the time of assembly and therefore was not sufficiently satisfactory in pressure release operation performance, although the weight of the battery can be reduced due to a decrease in the number of components.

Please amend the paragraphs at page 4, lines 1-19, to read as follows:

a9

In addition, another object of the present invention is to provide a method of manufacturing a lithium secondary battery which is simple for manufacturing and in which improvement in productivity has been achieved by structuring the electrode cap simply.

Summary of the Invention

According to the present invention, there is provided a lithium secondary battery comprising an internal electrode body formed by winding a positive electrode and a negative electrode on an outer periphery wall of the hollow cylindrical winding core and filling with nonaqueous electrolyte solution, a cylindrical battery case containing the internal electrode body inside with its both ends being open, a battery cap, internal terminals, and external terminals, and comprises electrode caps which have sealed the above described internal electrode body at both open ends of this battery case, wherein at least one of the electrode caps has a pressure release hole in a position corresponding to the center axis of the winding core.

Please amend the paragraphs at page 5, line 17 – page 6, line 13, to read as follows:

a10

In addition, according to the present invention, there is provided a lithium secondary battery which has an internal electrode body formed by winding a positive electrode and a negative electrode on an outer periphery wall of the hollow cylindrical winding core and dipping into nonaqueous electrolyte solution, a cylindrical battery case containing the internal electrode body inside with its both ends being open, battery caps

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at least one of which has a pressure release hole and which seal the above described internal electrode body at both open ends of this battery case, wherein a pressure release valve is disposed on the internal peripheral wall of or at the end of the above described pressure release hole with the elastic body and the metal foil being brought into pressure contact with a spacer to seal the above described battery case.

A10 Cont'd

The metal foil is preferably formed so as to have the surface pressure of not less than 980 kPa. The spacer is preferably formed with a metal material having a Young's modulus not less than 170 GPa, and is preferably a ring member having a stopper structure in order that the stress not less than a constant amount will not be applied to the ring member or the above described elastic body. Moreover, the metal foil is preferably made of Al, Cu, Ni, or alloys containing them respectively that is coated by the fluoride resin.

Please amend the paragraphs at page 7, line 1 – page 8, line 3, to read as follows:

A11

In addition, according to the present invention, there is provided a lithium secondary battery which has an internal electrode body formed by winding a positive electrode and a negative electrode on an outer peripheral wall of the hollow cylindrical winding core and dipped into nonaqueous electrolyte solution, a cylindrical battery case containing the internal electrode body inside with its both ends being open, and electrode caps which have sealed the above described internal electrode body at the both open ends of this battery case, wherein the above described electrode caps are formed in approximately rotary symmetry around the center axis of the above described battery case.

The lithium secondary battery of the present invention suitably has a battery capacity of not less than 2 Ah. The present invention can be suitably used as a battery to be mounted on vehicles, and for an engine starter, and moreover can be suitably used for an electric vehicle or a hybrid electric vehicle.

In addition, according to the present invention, there is provided a method of manufacturing a lithium secondary battery, which comprises: preparing a plate-like

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a11 cont'd

member functioning as a cap after production, an elastic body, a metal foil and a spacer which are processed in advance to a predetermined size; disposing said elastic body and said metal foil in a predetermined position; combining them with said spacer to form a pressure release hole unit; fitting said pressure release hole unit into said plate-like member to produce an electrode cap; preparing a second electrode cap; positioning an internal electrode body in a battery case; and sealing the battery case with said electrode caps.

Please amend the paragraph at page 9, lines 4 – 7, to read as follows:

a12

Figs. 7(a) and 7(b) show a perspective view and a sectional view, respectively, showing an embodiment of a component of a pressure release valve suitably used for the lithium secondary battery of the present invention.

Please amend the paragraphs at page 9, line 23 – page 11, line 8, to read as follows:

a13

The present invention is roughly divided into first to fourth aspects. Incidentally, the first to third aspects relates to a lithium secondary battery, and the fourth aspect relate to a manufacturing method of the lithium secondary battery. As follows, embodiments of the present invention on respective aspects will be described, but it goes without saying that the present invention is not limited to those embodiments.

A lithium secondary battery of the first aspect of the present invention is a lithium secondary battery which has an internal electrode body formed by winding a positive electrode and a negative electrode on an outer peripheral wall of the hollow cylindrical winding core and filling with nonaqueous electrolyte solution, a cylindrical battery case containing this internal electrode body inside with its both ends being open, a battery cap, internal terminals, and external terminals, and comprises electrode caps which have sealed the above described internal electrode body at both open ends of this battery case, and at least one of the electrode caps is configured by comprising a pressure release hole in a position corresponding to the center axis of the winding core. As shown in Fig. 1, if

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a13 cont'd

the winding core 13, which is hollow in the center, is disposed in the center of the battery case 24 with the pressure release hole 18 being a pressure release hole disposed in an extended position of the center axis of the winding core, the inner pressure can be reduced extremely swiftly. This serves to make it possible to prevent the burst of the battery with a pressure release hole being disposed at least on only one of the electrode caps. Accordingly, although pressure release holes conventionally used to be disposed in both the positive and negative electrode caps, a pressure release hole in either one will be sufficient, and the structure of one electrode cap which does not require a pressure release hole will become further simpler so that manufacturing costs can be reduced. Of course, pressure release holes may be disposed in both the positive and negative electrode caps in the present invention.

Please amend the paragraphs at page 12, line 7 – page 13, line 2, to read as follows:

a14

In addition, in the first aspect of the invention, it is preferable that the capacity (C) of the internal electrode body is not less than 2Ah, and the sectional area (S_1) of pressure release hole as well as the sectional area (S_2) of the hollow portion of the winding core are larger than 0.3 (cm^2). A battery with capacity of not less than 2Ah gives rise to a large quantity of gas at the time when abnormality in battery reaction such as short circuit, etc. has taken place. As shown in Fig. 2(a) and Fig. 2(b), in the case where the pressure release hole is provided in only one of the electrode caps, the winding core hollow portion will be the main pressure release path, and the result of an embodiment to be described later has revealed that also the battery with capacity of not less than 2Ah can implement pressure release without any problem if the pressure release hole's sectional area 32 and the winding core hollow portion's sectional area 33 are both larger than 0.3 (cm^2).

Here, "pressure release hole's sectional area" refers to, as shown in Figs. 2(a)-(d), the sectional area of the end portion the pressure release hole being an opening of the pressure release hole which is visible at the time when the electrode cap was viewed from the internal side of the battery.

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Please amend the paragraph at page 14, line 14 – page 15, line 16, to read as follows:

a15

Moreover, the size of the winding core's center hollow portion's sectional area (S_2) is preferably not less than the pressure release hole's sectional area (S_1). This reflects consideration on the flow of gas at the time of pressure release and the pressure balance. As shown in Fig. 2(a), in the case with one side pressure release hole, the gas 34 at the side without the pressure release hole undergoes pressure release through the center hollow portion of the winding core. Thus, smooth pressure release through the center hollow portion of the winding core will be indispensable. Firstly, the sectional area of the pressure release hole itself determines safety at the time of pressure release. In the case where the pressure release hole's sectional area is small, even if the winding core's center hollow portion's sectional area is not less than the pressure release hole's sectional area, the internal pressure is not smoothly released, and the battery is endangered to burst. In addition, also for the case where the winding core's center hollow portion's sectional area is small, the fact that the winding core's center hollow portion's sectional area is not less than the pressure release hole's sectional area will not make any difference. Accordingly, when the pressure release hole's sectional area and the winding core center hollow portion's sectional area are both larger than 0.3 (cm^2), and moreover the winding core's center hollow portion's sectional area is not less than the pressure release hole's sectional area, the winding core's center hollow portion's gas 34 flows sufficiently and results in a state that the area of the pressure release hole itself controls speed to provide the preferable pressure release function.

Please amend the paragraph at page 16, lines 7 –24, to read as follows:

a16

Next, the second aspect of the present invention will be described. A lithium secondary battery of the second aspect of the present invention is a lithium secondary battery which has an internal electrode body formed by winding a positive electrode and a negative electrode on an outer periphery wall of the hollow cylindrical winding core

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a16 Cont'd

and filling with nonaqueous electrolyte solution, a cylindrical battery case containing this internal electrode body inside with its both ends being open, electrode caps at least one of which has a pressure release hole and which seal the above described internal electrode body at both open ends of this battery case, and is configured by disposing a pressure release valve on the internal periphery wall of or at the end of the pressure release hole with an elastic body and the metal foil being brought into pressure contact with a spacer to seal the battery case. Since such a simple pressure release valve structure performs well in assembly work, costs for the lithium secondary battery can be reduced.

Please amend the paragraph at page 17, line 24 – page 18, line 11, to read as follows:

a17

Moreover, a spacer is preferably a ring member or a ring member having stopper structure in order that the stress not less than a constant amount will not be applied to the elastic body. The electrode cap is, as shown in Fig. 3, designed so that a spacer is pressed for insertion with an angle from the upper portion of the pressure release hole 18 to the lower portion thereof to bring the elastic body as well as the metal foil into pressure contact and fixing and an appropriate surface pressure is applied to the metal foil. In addition, as shown in Fig. 4, the reason why the spacer 26 comprises a stopper structure is for making sure that the spacer shall not be pushed into inside the pressure release hole to a degree not less than necessary and no pressure to an excess degree shall applied to the elastic body and the like to be broken.

Please amend the paragraphs at page 18, line 21 – page 20, line 2, to read as follows:

a18

In addition, in the second aspect of the invention, for a metal foil, ones made of Al, Cu, Ni, or alloys containing them respectively that are coated by the fluoride resin are suitably used. The metal foil, which will be brought into direct contact with electrolyte solution, is preferably highly pure and excellent in anti-corrosion against electrolyte solution for use, and one having surfaces coated with fluoride resin should be used to provide improvement in tolerance and excellent safety.

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a18 Cont'd

Moreover, in the second aspect of the invention, the pressure contact force applied to the elastic body is preferably not less than 980 kPa and not more than the force amount to cause the elastic body to maintain elasticity maintenance percentage of not less than 95%. This enables the surface pressure of the metal foil to be secured and the air-tightness to be maintained so that leakage of the electrolyte solution is prevented. At this time, as the elastic body, an elastic body processed in advance to a predetermined size, that is, packing is preferably used, and as materials in particular, ethylene propylene rubber, polyethylene, polypropylene or fluoride resin are nominated. These resins are excellent in anticorrosion, and even if the nonaqueous electrolyte solution containing an organic solvent of an ester system is used, reliability is secured.

The elasticity maintenance percentage of the elastic body is expressed by changes in thickness before and after the pressure contact force has been applied with an autograph to an elastic body of 'for example' the outer diameter of 10 mmϕ × the inner diameter of 7 mmϕ × 1 mm, that is, when the pressure contact force is released after a predetermined time lapse. That is, the elasticity maintenance percentage D of the elastic body is given by $D=B_1/A_1 \times 100$ with A_1 being thickness of the elastic body prior to application of the pressure contact force and B_1 being thickness of the elastic body after application of the pressure contact force.

Please amend the paragraphs at page 20, line 21 – page 22, line 25, to read as follows:

a19

Next, the pressure release valve disposed in the above described electrode cap will be described in detail. Fig. 3 is an enlarged sectional view showing the structure of the pressure release valve 20 shown in Fig. 1. The pressure release valve 20 is configured by comprising a metal foil 19, the elastic body 17, and a ring-form metal spacer 26 in order from the lower portion of the battery cap 15. This is a basic configuration in the present invention, but also in this case, the electrode cap is inclined with a degree, and in order to control the deformation amount of the elastic body homogeneously, the stopper portion 27 is provided to the battery cap 15 so that the spacer 26 is not structured to be pushed into the side of the elastic body 17 in not less than a

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a19 Cont'd.

predetermined amount. This serves to make it possible that the appropriate stress to the elastic body and the necessary surface pressure of the metal foil is secured and the air tightness of the pressure release valve 20 is maintained. At this occasion, the metal spacer is further preferably fixed with an adhesive agent 28 in order to secure air tightness firmly also under a low temperature to be used. For this adhesive agent, an aerobic adhesive agent is suitably used.

Another embodiment of the pressure release valve is shown in Fig. 4. The pressure release valve 20 is configured by comprising a metal foil 19, the elastic body 17, and a ring-form metal spacer 26 having stopper structure in order from the lower portion of the battery cap. In this case, the surface pressure applied to the metal foil 19 is controlled more firmly so as to enhance its function as a pressure release valve. That is, the present invention is under the state that the packing being an elastic body is pressured and flattened, or stress is being applied to the elastic body all the time, and if it is applied to an excess degree, elasticity will be gone and function as the pressure release valve as a whole will be lost. Therefore, a reception portion on the stress has been created so that the stress has been controlled to not more than a predetermined amount more firmly.

Another embodiment of the pressure release valve is shown in Fig. 5. The pressure release valve 20 is configured by comprising the elastic body 17, a metal foil 19, and a ring-form metal spacer 26 having stopper structure in order from the lower portion of the electrode cap. Thus, configuration by comprising the metal foil 19 sandwiched between the elastic body 17 and the metal spacer 26C is realizable, and this combination, as shown in Figs. 7(a) and 7(b), enables the respective components of the pressure release valve to be integrated in advance as a pressure release hole unit 29.

In the case where the above described pressure release valves of Figs. 3, 4 and 5 are used, for any of the cases, in the state of the single body of the electrode cap prior to assembly of the battery, with only the metal foil and the elastic body being mounted, and with the metal spacer being inserted by pressure and the like the pressure release hole 18 comprising the pressure release valves having pressure release operating nature can be formed to make it possible to attain excellent effects such as further reduction in

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a19 contd

equipment costs, simplification of assembly work, and improvement in manufacturing yield factor.

Please amend the paragraphs at page 23, line 7 – page 27, line 11, to read as follows:

a20

In addition, in the first and the second aspects of the invention, the pressure release hole is preferably commonly used as the electrolyte solution inlet. In the first and the second aspect of the invention, the pressure release hole is disposed in the center of the electrode cap so that, as described later the pressure release hole can be used as an electrolyte solution inlet. That is, as shown in Fig. 1, the pressure release hole is integrated with the external terminal and is disposed in the center of the electrode cap, and moreover the internal electrode body's winding core is disposed in the center of the battery so that the electrolyte solution can be injected with that pressure release hole. This serves to make it possible to shorten time for injecting the electrolyte solution, to reduce loss in the electrolyte solution, to reduce the hole's area in the battery, and thus to largely reduce the probability of leakage of the electrolyte solution.

As for that electrolyte solution injection method, as shown in Fig. 9, one uses the pressure release hole as the electrolyte solution inlet 31 prior to sealing the battery case 24 with it by inserting the electrolyte solution injection nozzle 25 into the center hollow portion of the winding core 13. Adoption of this method serves to make it possible to insert the tip of the electrolyte solution injection nozzle 25 into the other end of the battery 14 so that the electrolyte solution is injected well.

In this occasion, the battery 14 is disposed in a space such as a glove box and the like where the atmosphere can be adjusted. When the interior of the glove box, etc. is evacuated with a vacuum pump, the battery 14 is in a state that the pressure release hole is used as an electrolyte inlet, and therefore the interior of the battery 14 will be in a vacuum. Here, the vacuum level is preferably made to enter the state of vacuum higher than around 0.1 torr (13.3 Pa).

Under this state, the tip of the nozzle 25 is inserted through the electrolyte inlet 31, and subsequently through the center hollow portion of the winding core 13 to reach

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A20 Cont'd.

the position of the end surface of the internal electrode body 1 in the bottom side of the battery, that is, the position indicated by the broken line AA' in Fig. 9, and thereafter the electrolyte solution is injected until the internal electrode body 1 is filled, that is, to the position indicated by the broken line BB' in Fig. 9. Here, insertion of tip of the nozzle 25 to reach the lowest portion inside the battery 14 can prevent the electrolyte solution from splashing so as to start dipping into the electrolyte solution the internal electrode body 1 from the end surface of the bottom surface portion without fail.

Incidentally, during the dipping process of the electrolyte solution, the vacuum level is preferably maintained approximately in such a degree that the electrolyte solution will not boil, and the vacuum level at this time largely depends on the nature of the solvent composing the electrolyte solution being used. In addition, as the material quality for the injection nozzle 25, metals or resins which will not undergo corrosion by the electrolyte solution are used, and the injection nozzle 25 is connected with the electrolyte reserve tank disposed outside the glove box, etc. via a tube or a pipe, etc. so that the electrolyte is transported from the electrolyte reserve tank with a quantitative pump, etc.

Thus, the battery 14 is filled with the electrolyte solution from the follower portion so that the internal electrode body 1 is filled from the lower portion to the upper portion, bubbles generated from the internal electrode body 1 can come out through the space which is not filled with electrolyte solution, filling by the electrolyte solution will be able to be implemented efficiently. Thus, injection time of the electrolyte solution can be shortened, and in this case, even in the case where a highly volatile solvent is contained in the electrolyte solution, its evaporation quantity can be suppressed to the smallest limit so as to prevent the electrolyte solution's performance from dropping.

In addition, the lithium secondary battery of the third aspect of the present invention is a lithium secondary battery, which has an internal electrode formed by winding a positive electrode and a negative electrode on an outer periphery wall of the hollow cylindrical winding core and filled with nonaqueous electrolyte solution, a cylindrical battery case containing this internal electrode body inside with its both ends being open, and electrode caps which have sealed the above described internal electrode body at both open ends of this battery case, and the electrode caps are configured to be

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formed in approximately rotary symmetry around the center axis of the battery case. As in the first and the second aspect of the invention, if the electrode cap comprises a pressure release hole in a position of corresponding with the center axis of the winding core, the winding core is disposed on the center axis of the battery case, and the pressure release hole is structured to be integrated with the external terminal, and the pressure release hole is used in common as the electrolyte solution inlet, as shown in Fig. 8(a), the electrode cap will be able to be formed in approximately rotary symmetry around the center axis of the battery case.

a20 Cont'd

In the lithium secondary battery, in order to accelerate penetration of the solution into the internal electrode body in the injection operation of the electrolyte solution, the electrolyte solution might be poured from the upper portion of the internal electrode body. In this case, as shown in Fig. 8(b), the electrode cap preferably has a slits 30 formed by providing slits in the internal electrode portion. The number of these slits can, as shown in Fig. 8(c), 8(d), and 8(e), be provided corresponding with necessity, and there is no limitation on its number or position. Here, approximately rotary symmetry of the electrode cap in the present invention has a broad meaning, including complete rotary symmetry to the one in which a slit is formed as shown in Fig. 8(b).

Please amend the paragraph at page 28, lines 9 – 14, to read as follows:

a21

The present invention includes a lithium secondary battery in which the pressure release valve is used as a safety mechanism for burst prevention of the battery. Accordingly, there is no limitation on other materials or battery structure. Main members comprising the battery and their structures will be generally described as follows.

Please amend the paragraphs at page 29, line 8 – page 30, line 8, to read as follows:

a22

Another structure of the electrode body is a lamination type, which is configured by laminating a plurality of layers of single cell type electrode bodies used for a coin cell. As shown in Fig. 13, a lamination-type electrode body 7 comprises positive electrode

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plates 8 and negative electrode plates 9 each having predetermined forms and separators 10, the positive electrode plates 8 and the negative electrode plates 9 being laminated through the separators alternately, and at least one electrode lead 11 or 12 is attached to each sheet of electrode plates 8 and 9. Materials to be used, and the producing method, etc. for the electrode plates 8 and 9 are similar to those in the electrode plates 2 and 3, etc. for the wound-type electrode body 1.

A22 Cont'd

Next, with the wound-type electrode body 1 as an example, its configuration will be described further in detail. The positive electrode plate 2 is produced by applying positive active substance onto the both surfaces of the electricity collection substrate. As the electricity collection substrate, a metal foil such as an aluminum foil or a titanium foil, etc., which is good in corrosion resistance against positive electrochemical reaction, is used, but other than foils, punching metal or mesh may be used. In addition, as the positive active substance, a lithium transition metal compound oxide such as lithium manganese oxide ($LiMn_2O_4$), lithium cobalt oxide ($LiCoO_2$), lithium nickel oxide ($LiNiO_2$) are suitably used, and preferably carbon powder such as acetylene black and the like are added to these as conduction assistant agent.

Please amend the paragraph at page 32, lines 3 – 9, to read as follows:

A23

For assembly of the battery, at first, conductivity between the terminals to extract currents to outside and the electrode leads 5 and 6 is secured while the produced electrode body 1 is inserted into the battery case and is held in a stable position. Thereafter, after they are filled with the nonaqueous electrolyte solution, the battery case is sealed, and thus the battery is produced.

Please amend the paragraph at page 32, lines 17 – 25, to read as follows:

A24

As the lithium compound to be dissolved into such solvent, that is, an electrolyte, lithium fluoride complex compound such as hexafluoride lithium phosphate ($LiPF_6$), lithium fluoroborate ($LiBF_4$), etc. or lithium halide such as lithium perchlorate ($LiClO_4$)

a24 cont'd

[CLEAN VERSION OF PARAGRAPHS INCORPORATING CHANGES MADE]

can be used, and one or more kinds are dissolved into the above described solvent for use. In particular, it is preferable that $LiPF_6$ is used, which hardly causes oxidation decomposition and involves electrolyte solution with high conductivity.

Please amend the paragraph at page 33, lines 7 – 26, to read as follows:

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a25

A battery related to the examples 1 to 4 and the comparative examples 1 to 4 has a wound-type electrode body fabricated with a positive electrode plate produced by coating the positive agent slurry with $LiMn_2O_4$ spinel as a positive active substance to which acetylene black as a conductive assistant agent at an external ratio of 4% by weight was added and moreover a solvent and a binder were added to the both surfaces of the aluminum foil of thickness 20 μm to make thickness of approximately 100 μm respectively and a negative electrode plate produced by coating carbon powder as a negative active substance to the both surfaces of the copper foil of thickness 10 μm to make thickness of approximately 80 μm respectively in addition to the similar method hereof, and after it is contained in a battery case of outer diameter of 50 mmϕ, nonaqueous electrolyte solution in which $LiPF_6$ as an electrolyte was dissolved into the equal volume mixture solvent of EC and DEC at concentration of 1 mol/l was filled. Incidentally, an Al pipe was used as the winding core, and ethylene propylene rubber with thickness of 1 mm was used as packing for production.

VERSION OF PARAGRAPHS WITH MARKINGS TO SHOW CHANGES MADE

Page 1, line 21 – page 2, line 27:

This lithium secondary battery is advantageous in that it has high operating voltage and high energy density and can discharge a large current, but is inconvenient in that the rise of a battery temperature caused by abnormalities at the time of charging or discharging, for example, over-discharging due to a short circuit of external terminals, or over-charging due to malfunction of a charging device accompanies the rise of inner pressure resulting in a burst of the battery. Accordingly, the lithium secondary battery comprises a pressure release hole in an electrode cap being its component as a safety mechanism for preventing this burst, and on the inner periphery wall or at the end of the ~~a~~ pressure release hole a pressure release valve is disposed. As shown in Fig. 10, conventionally this pressure release hole 18 is disposed in the vicinity of the outer periphery of the electrode cap apart from the central axis of the battery case 24.

However, the pressure release hole disposed in the vicinity of the outer periphery of the electrode cap must be disposed in ~~the~~ both of the positive and the negative electrode caps, otherwise, insufficiency in releasing gasses from the center hollow portion of the winding core (which contains a lot of gases to cause inner pressure increase) makes it impossible to prevent the battery from bursting which used to be a problem. In addition, when a pressure release hole is disposed in the vicinity of the outer periphery of the electrode cap, electrolyte solution inlet must be disposed separately, and since the electrode cap requires two holes, the area of the portions to be sealed will become large, giving rise to aptness of leakage of the electrolyte solution, which used to be a problem.

Page 3, lines 7 – 18:

In addition, conventionally, the pressure release valve is configured as shown in Fig. 11 by pressing an airtight ring 44 for fixing with a pressure fixing ring 43 where a hole 42 is provided in a battery case 41 (reference should be made to Japanese Patent Laid-Open No. 11-49217, etc.). However, ~~in~~ Japanese Patent Laid-Open No. 11-49217

VERSION OF PARAGRAPHS WITH MARKINGS TO SHOW CHANGES MADE

did not disclose any solving means such as particular shapes of components of the pressure release valve and the fixing pressure at the time of assembly and therefore was not sufficiently satisfactory in pressure release operation performance, although the weight of the battery can be reduced due to a decrease in the number of components.

Page 4, lines 1-19:

In addition, another object of the present invention is to provide a method of manufacturing a lithium secondary battery which is simple for manufacturing and in which improvement in productivity has been ~~planed~~ achieved by structuring the electrode cap simply.

Summary of the Invention

According to the present invention, there is provided a lithium secondary battery comprising an internal electrode body formed by winding a positive electrode and a negative electrode on an outer periphery wall of the hollow cylindrical winding core and ~~dipped into~~ filling with nonaqueous electrolyte solution, a cylindrical battery case containing the internal electrode body inside with its both ends being open, a battery cap, internal terminals, and external terminals, and comprises electrode caps which have sealed the above described internal electrode body at ~~the~~ both open ends of this battery case, wherein at least one of the electrode caps has a pressure release hole in a position corresponding to the center axis of the winding core.

Page 5, line 17 – page 6, line 13:

In addition, according to the present invention, there is provided a lithium secondary battery which has an internal electrode body formed by winding a positive electrode and a negative electrode on an outer periphery wall of the hollow cylindrical winding core and ~~dipped~~ dipping into nonaqueous electrolyte solution, a cylindrical

VERSION OF PARAGRAPHS WITH MARKINGS TO SHOW CHANGES MADE

battery case containing the internal electrode body inside with its both ends being open, battery caps at least one of which has a pressure release hole and which seal the above described internal electrode body at ~~the~~ both open ends of this battery case, wherein a pressure release valve is disposed on the internal ~~periphery~~ peripheral wall of or at the end of the above described pressure release hole with the elastic body and the metal foil being brought into pressure contact with a spacer to seal the above described battery case.

The metal foil is preferably formed so as to have the surface pressure of not less than 980 kPa. The spacer is preferably formed with a metal material having a Young's modulus not less than 170 GPa, and is preferably a ring member having a stopper structure in order that the stress not less than a constant amount will not be applied to the ring member or the above described elastic body. Moreover, the metal foil is preferably made of Al, Cu, Ni, or alloys containing them respectively that is coated by the fluoride resin.

Page 7, line 1 – page 8, line 3:

In addition, according to the present invention, there is provided a lithium secondary battery which has an internal electrode body formed by winding a positive electrode and a negative electrode on an outer ~~periphery~~ peripheral wall of the hollow cylindrical winding core and dipped into nonaqueous electrolyte solution, a cylindrical battery case containing the internal electrode body inside with its both ends being open, and electrode caps which have sealed the above described internal electrode body at the both open ends of this battery case, wherein the above described electrode caps are formed in approximately rotary symmetry around the center axis of the above described battery case ~~being a center~~.

The lithium secondary battery of the present invention ~~are suitable to a battery with the~~ suitably has a battery capacity of not less than 2 Ah. The present invention can be suitably used as a battery to be mounted on vehicles, and for an engine starter, and moreover can be suitably used for an electric vehicle or a hybrid electric vehicle.

VERSION OF PARAGRAPHS WITH MARKINGS TO SHOW CHANGES MADE

In addition, according to the present invention, there is provided ~~A~~ a method of manufacturing a lithium secondary battery, which comprises: preparing a plate-like member functioning as a cap after production, an elastic body, a metal foil and a spacer which are processed in advance to a predetermined size; disposing said elastic body and said metal foil in a predetermined position; combining them with said spacer to form a pressure release hole unit; fitting said pressure release hole unit into said plate-like member to produce an electrode ~~caps~~ cap; preparing a second electrode cap; ~~containing~~ positioning an internal electrode body in a battery case; and sealing the battery case with said electrode caps.

Page 9, lines 4 – 7:

~~Fig. 7 shows~~ Figs. 7(a) and 7(b) show a perspective view and a sectional view, respectively, showing an embodiment of a component of a pressure release valve suitably used for the lithium secondary battery of the present invention.

Page 9, line 23 – page 11, line 8:

The present invention is roughly divided into first to fourth aspects. Incidentally, the first to third aspects relates to a lithium secondary battery, and the fourth aspect ~~relates~~ relate to a manufacturing method of the lithium secondary battery. As follows, embodiments of the present invention on respective aspects will be described, but it goes without saying that the present invention is not limited to those embodiments.

A lithium secondary ~~batter~~ battery of the first aspect of the present invention is a lithium secondary battery which has an internal electrode body formed by winding a positive electrode and a negative electrode on an outer ~~periphery~~ peripheral wall of the hollow cylindrical winding core and ~~dipped into~~ filling with nonaqueous electrolyte solution, a cylindrical battery case containing this internal electrode body inside with its both ends being open, a battery cap, internal terminals, and external terminals, and comprises electrode caps which have sealed the above described internal electrode body

VERSION OF PARAGRAPHS WITH MARKINGS TO SHOW CHANGES MADE

at ~~the~~ both open ends of this battery case, and at least one of the electrode caps is configured by comprising a pressure release hole in a position corresponding to the center axis of the winding core. As shown in Fig. 1, if the winding core 13, which is hollow in the center, is disposed in the center of the battery case 24 with the pressure release hole 18 being a pressure release hole disposed in an extended position of the center axis of the winding core, the inner pressure can be reduced extremely swiftly. This serves to make it possible to prevent the burst of the battery with a pressure release hole being disposed at least on only one of the electrode caps. Accordingly, although pressure release holes conventionally used to be disposed in ~~the~~ both ~~parties of~~ the positive and negative electrode caps, ~~one party~~ a pressure release hole in either one will be sufficient, and the structure of one electrode cap which does not require a pressure release hole will become further simpler so that manufacturing costs can be reduced. Of course, pressure release holes may be disposed in ~~the~~ both ~~parties of~~ the positive and negative electrode caps in the present invention.

Page 12, line 7 – page 13, line 2:

In addition, in the first aspect of the invention, it is preferable that the capacity (C) of the internal electrode body is not less than 2Ah, and the sectional area (S_1) of pressure release hole as well as the sectional area (S_2) of the hollow portion of the winding core are larger than 0.3 (cm^2). A battery with capacity of not less than 2Ah gives rise to a large quantity of gas at the time when abnormality in battery reaction such as short circuit, etc. has taken place. As shown in Fig. 2(a) and Fig. 2(b), in the case where the pressure release hole is provided in only one of the electrode caps, the winding core hollow portion ~~32~~ will be the main pressure release path, and the result of an embodiment to be described later has revealed that also the battery with capacity of not less than 2Ah can implement pressure release without any problem if the pressure release hole's sectional area ~~31~~ 32 and the winding core hollow portion's sectional area ~~32~~ 33 are both larger than 0.3 (cm^2).

VERSION OF PARAGRAPHS WITH MARKINGS TO SHOW CHANGES MADE

Here, "pressure release hole's sectional area" refers to, as shown in Figs. 2(a)-(d), the sectional area ~~31~~ of the end portion the pressure release hole being an opening of the pressure release hole which is visible at the time when the electrode cap was viewed from the internal side of the battery.

Page 14, line 14 – page 15, line 16:

Moreover, the size of the winding core's center hollow portion's sectional area (S_2) is preferably not less than the pressure release hole's sectional area (S_1). This reflects consideration on the flow of gas at the time of pressure release and the pressure balance. As shown in Fig. 2(a), in the case with one side pressure release hole, the gas 34 at the side without the pressure release hole undergoes pressure release through the center hollow portion of the winding core. Thus, smooth pressure release through the center hollow portion of the winding core will be indispensable. Firstly, the sectional area of the pressure release hole itself determines safety at the time of pressure release. In the case where the pressure release hole's sectional area is small, even if the winding core's center hollow portion's sectional area is not less than the pressure release hole's sectional area, the internal pressure is not smoothly released, and the battery is endangered to burst. In addition, also for the case where the winding core's center hollow portion's sectional area is small, the fact that the winding core's center hollow portion's sectional area is not less than the pressure release hole's sectional area will not make any difference. Accordingly, when the pressure release hole's sectional area and the winding core center hollow portion's sectional area are both larger than 0.3 (cm^2), and moreover the winding core's center hollow portion's sectional area is not less than the pressure release hole's sectional area, the winding core's center hollow portion's gas 34 flows sufficiently and results in a state that the area of the pressure release hole itself controls speed to provide the preferable pressure release function.

Page 16, lines 7 –24:

VERSION OF PARAGRAPHS WITH MARKINGS TO SHOW CHANGES MADE

Next, the second aspect of the present invention will be described. A lithium secondary battery of the second aspect of the present invention is a lithium secondary battery which has an internal electrode body formed by winding a positive electrode and a negative electrode on an outer periphery wall of the hollow cylindrical winding core and ~~dipped into~~ filling with nonaqueous electrolyte solution, a cylindrical battery case containing this internal electrode body inside with its both ends being open, electrode caps at least one of which has a pressure release hole and which seal the above described internal electrode body at ~~the~~ both open ends of this battery case, and is configured by disposing a pressure release valve on the internal periphery wall of or at the end of the pressure release hole with ~~the~~ an elastic body and the metal foil being brought into pressure contact with a spacer to seal the battery case. Since such a simple pressure release valve structure performs well in assembly work, costs for the lithium secondary battery can be reduced.

Page 17, line 24 – page 18, line 11:

Moreover, a spacer is preferably a ring member or a ring member having stopper structure in order that the stress not less than a constant amount will not be applied to the elastic body. The electrode cap is, as shown in Fig. 3, designed so that a spacer is pressed for insertion with an angle from the upper portion of the pressure release hole ~~18A~~ 18 to the lower portion thereof to bring the elastic body as well as the metal foil into pressure contact and fixing and an appropriate surface pressure is applied to the metal foil. In addition, as shown in Fig. 4, the reason why the spacer ~~26B~~ 26 comprises a stopper structure is for making ~~it~~ sure that the spacer shall not be pushed into inside the pressure release hole to a degree not less than necessary and no pressure to an excess degree shall applied to the elastic body and the like to be broken.

Page 18, line 21 – page 20, line 2:

VERSION OF PARAGRAPHS WITH MARKINGS TO SHOW CHANGES MADE

In addition, in the second aspect of the invention, for a metal foil, ~~the one~~ ones made of Al, Cu, Ni, or alloys containing them respectively that are coated by the fluoride resin are suitably used. The metal foil, which will be brought into direct contact with electrolyte solution, is ~~the~~ preferably highly pure ~~one~~ and excellent in anti-corrosion against electrolyte solution for use, and ~~the~~ one having surfaces coated with fluoride resin should be used ~~so that the one in which~~ to provide improvement in tolerance ~~is planned~~ and excellent ~~in~~ safety.

Moreover, in the second aspect of the invention, the pressure contact force applied to the elastic body is preferably not less than 980 kPa and not more than the force amount to cause the elastic body to maintain elasticity maintenance percentage of not less than 95%. This enables the surface pressure of the metal foil to be secured and the air-tightness to be maintained so that leakage of the electrolyte solution is prevented. At this time, as the elastic body, an elastic body processed in advance to a predetermined size, that is, packing is preferably used, and as materials in particular, ethylene propylene rubber, polyethylene, polypropylene or fluoride resin are nominated. These resins are excellent in anticorrosion, and even if the nonaqueous electrolyte solution containing an organic solvent of ~~a~~ an ester system is used, reliability is secured.

The elasticity maintenance percentage of the elastic body is expressed by changes in thickness before and after the pressure contact force has been applied with an autograph to an elastic body of 'for example' the outer diameter of 10 mmϕ $\times$ the inner diameter of 7 mmϕ $\times$ 1 mm, that is, when the pressure contact force is released after a predetermined time ~~lapses~~lapse. That is, the elasticity maintenance percentage D of the elastic body is given by $D=B_1/A_1 \times 100$ with A_1 being thickness of the elastic body prior to application of the pressure contact force and B_1 being thickness of the elastic body after application of the pressure contact force.

Page 20, line 21 – page 22, line 25:

Next, the pressure release valve disposed in the above described electrode cap will be described in detail. Fig. 3 is an enlarged sectional view showing the structure of

VERSION OF PARAGRAPHS WITH MARKINGS TO SHOW CHANGES MADE

the pressure release valve 20 shown in Fig. 1. The pressure release valve ~~20A~~ 20 is configured by comprising a metal foil 19, the elastic body ~~17A~~ 17, and a ring-form metal spacer ~~26A~~ 26 in order from the lower portion of the battery cap ~~15A~~ 15. This is a basic configuration in the present invention, but also in this case, the electrode cap is inclined with a degree, and in order to control the deformation amount of the elastic body homogeneously, the stopper portion ~~27A~~ 27 is provided to the battery cap ~~15A~~ 15 so that the spacer ~~26A~~ 26 is not structured to be pushed into the side of the elastic body ~~17A~~ 17 in not less than a predetermined amount. This serves to make it possible that the appropriate stress to the elastic body and the necessary surface pressure of the metal foil is secured and the air tightness of the pressure release valve ~~20A~~ 20 is maintained. At this occasion, the metal spacer is further preferably fixed with an adhesive agent 28 in order to secure air tightness firmly also under a low temperature to be used. For this adhesive agent, an aerobic adhesive agent is suitably used.

Another embodiment of the pressure release valve is shown in Fig. 4. The pressure release valve ~~20B~~ 20 is configured by comprising a metal foil 19, the elastic body ~~17B~~ 17, and a ring-form metal spacer ~~26B~~ 26 having stopper structure in order from the lower portion of the battery cap. ~~This is the one in which~~ In this case, the surface pressure applied to the metal foil 19 is controlled more firmly so as to enhance its function as a pressure release valve. That is, the present invention is under the state that the packing being an elastic body is pressured and flattened, or stress is being applied to the elastic body all the time, and if it is applied to an excess degree, elasticity will be gone and function as the pressure release valve as a whole will be lost. Therefore, a reception portion on the stress has been created so that the stress has been controlled to not more than a predetermined amount more firmly.

Another embodiment of the pressure release valve is shown in Fig. 5. The pressure release valve ~~20C~~ 20 is configured by comprising the elastic body ~~17C~~ 17, a metal foil 19, and a ring-form metal spacer ~~26C~~ 26 having stopper structure in order from the lower portion of the electrode cap. Thus, configuration by comprising the metal foil 19 sandwiched between the elastic body ~~17C~~ 17 and the metal spacer 26C is realizable, and this combination, as shown in ~~Fig. 7~~ Figs. 7(a) and 7(b), enables the respective

VERSION OF PARAGRAPHS WITH MARKINGS TO SHOW CHANGES MADE

components of the pressure release valve to be integrated in advance as a pressure release hole unit 29.

In the case where the above described pressure release valves ~~20A, 20B, and 20C~~ of Figs. 3, 4 and 5 are used, for any of the cases, in the state of the single body of the electrode cap prior to assembly of the battery, with only the metal foil and the elastic body being mounted, and with the metal spacer being inserted by pressure and the like the pressure release hole 18 comprising the pressure release valves ~~20A, 20B, and 20C~~ having pressure release operating nature can be formed to make it possible to attain excellent effects such as further reduction in equipment costs, simplification of assembly work, and improvement in manufacturing yield factor.

Page 23, line 7 – page 27, line 11:

In addition, in the first and the second aspects of the invention, the pressure release hole is preferably commonly used as the electrolyte solution inlet. In the first and the second aspect of the invention, the pressure release hole is disposed in the center of the electrode cap so that, as described later the pressure release hole can be used as an electrolyte solution inlet. That is, as shown in Fig. 1, the pressure release hole is integrated with the external terminal and is disposed in the center of the electrode cap, and moreover the internal electrode body's winding core is disposed in the center of the battery so that the electrolyte solution can be injected with that pressure release hole. This serves to make it possible to shorten time for injecting the electrolyte solution, to reduce loss in the electrolyte solution, to reduce the hole's area in the battery, and thus to largely reduce the probability ~~in~~ of leakage of the electrolyte solution.

As for that electrolyte solution injection method, as shown in Fig. 9, ~~the~~ one uses the pressure release hole as the electrolyte solution inlet 31 prior to sealing the battery case 24 with it ~~and implements~~ by inserting the electrolyte solution injection nozzle 25 into the center hollow portion of the winding core 13. Adoption of this method serves to make it possible to insert the tip of the electrolyte solution injection nozzle 25 into the other end of the battery 14 so that the electrolyte solution is injected well.

VERSION OF PARAGRAPHS WITH MARKINGS TO SHOW CHANGES MADE

In this occasion, the battery 14 is disposed in ~~the~~ a space such as a ~~globe~~ glove box and the like where the atmosphere can be adjusted. When the interior of the ~~globe~~ glove box, etc. is ~~made to be vacuumed atmosphere~~ evacuated with a vacuum pump, the battery 14 is in a state that the pressure release hole is used ~~in common~~ as an electrolyte inlet, and therefore the interior of the battery 14 will be in a vacuum ~~atmosphere~~. Here, the vacuum level is preferably made to enter the state of vacuum higher than around 0.1 torr (13.3 Pa).

Under this state, the tip of the nozzle 25 is inserted through the electrolyte inlet 31, and subsequently through the center hollow portion of the winding core 13 to reach the position of the end surface of the internal electrode body 1 in the bottom side of the battery, that is, the position indicated by the broken line AA' in Fig. 9, and thereafter the electrolyte solution is injected until the internal electrode body 1 is ~~dipped~~ filled, that is, to the position indicated by the broken line BB' in Fig. 9. Here, insertion of tip of the nozzle 25 to reach the lowest portion inside the battery 14 can prevent the electrolyte solution from splashing so as to start dipping into the electrolyte solution the internal electrode body 1 from the end surface of the bottom surface portion without fail.

Incidentally, during the dipping process of the electrolyte solution, the vacuum level is preferably maintained approximately in such a degree that the electrolyte solution will not boil, and the vacuum level at this time largely depends on the nature of the solvent composing the electrolyte solution being used. In addition, as the material quality for the injection nozzle 25, metals or resins which will not undergo corrosion by the electrolyte solution are used, and the injection nozzle 25 is connected with the electrolyte reserve tank disposed outside the ~~globe~~ glove box, etc. via a tube or a pipe, etc. so that the electrolyte is transported from the electrolyte reserve tank with a quantitative pump, etc.

Thus, the battery 14 is filled with the electrolyte solution from the follower portion so that the internal electrode body 1 is ~~dipped~~ filled from the lower portion to the upper portion, ~~the bubble~~bubbles generated from the internal electrode body 1 can come out through the space which is not ~~dipped into the~~ filled with electrolyte solution, ~~dipping~~ filling by the electrolyte solution will be able to be implemented efficiently. Thus, injection time of the electrolyte solution can be shortened, and in this case, even in the

VERSION OF PARAGRAPHS WITH MARKINGS TO SHOW CHANGES MADE

case where a highly volatile solvent is contained in the electrolyte solution, its evaporation quantity can be suppressed to the smallest limit so as to prevent the electrolyte solution's performance from dropping.

In addition, the lithium secondary battery of the third aspect of the present invention is a lithium secondary battery, which has an internal electrode formed by winding a positive electrode and a negative electrode on an outer periphery wall of the hollow cylindrical winding core and ~~dipped into~~ filled with nonaqueous electrolyte solution, a cylindrical battery case containing this internal electrode body inside with its both ends being open, and electrode caps which have sealed the above described internal electrode body at ~~the~~ both open ends of this battery case, and the electrode caps are configured to be formed in approximately rotary symmetry around the center axis of the battery case ~~being a center~~. As in the first and the second aspect of the invention, if the electrode cap comprises a pressure release hole in a position of corresponding with the center axis of the winding core, the winding core is disposed on the center axis of the battery case, and the pressure release hole is structured to be integrated with the external terminal, and the pressure release hole is used in common as the electrolyte solution inlet, as shown in Fig. 8(a), the electrode cap will be able to be formed in approximately rotary symmetry around the center axis of the battery case ~~being a center~~.

In the lithium secondary battery, in order to accelerate penetration of the solution into the internal electrode body in the injection operation of the electrolyte solution, the electrolyte solution might be poured from the upper portion of the internal electrode body. In this case, as shown in Fig. 8(b), the electrode cap preferably has a slits 30 formed by providing slits in the internal electrode portion. The number of these slits can, as shown in Fig. 8(c), 8(d), and 8(e), be provided corresponding with necessity, and there is no limitation on its number or position. Here, approximately rotary symmetry of the electrode cap in the present invention has a ~~wide mean~~broad meaning, including complete rotary symmetry to the one in which a slit is formed as shown in Fig. 8(b).

Page 28, lines 9 – 14:

VERSION OF PARAGRAPHS WITH MARKINGS TO SHOW CHANGES MADE

The present invention includes a lithium secondary battery ~~of the present invention is the one~~ in which the pressure release valve is used as a safety mechanism for burst prevention of the battery. Accordingly, there is no limitation on other materials or battery structure. Main members comprising the battery and their structures will be generally described as follows.

Page 29, line 8 – page 30, line 8:

~~As another~~ Another structure of the electrode body~~,~~ is a lamination type, which is configured by laminating a plurality of layers of single cell type electrode bodies used for a coin cell~~, is nominated~~. As shown in Fig. 13, a lamination-type electrode body 7 ~~is the one comprising~~comprises ~~a~~ positive electrode ~~plate~~ plates 8 and ~~a~~ negative electrode ~~plate~~ plates 9 ~~both~~ each having predetermined forms and ~~a separator~~separators 10, the positive electrode ~~plate~~ plates 8 and the negative electrode ~~plate~~ plates 9 being laminated through the ~~separator~~ separators alternately, and at least one electrode lead 11 or 12 is attached to ~~one~~ each sheet of electrode plates 8 and 9. Materials to be used, and the producing method, etc. for the electrode plates 8 and 9 are similar to those in the electrode plates 2 and 3, etc. for the wound-type electrode body 1.

Next, with the wound-type electrode body 1 as an example, its configuration will be described further in detail. The positive electrode plate 2 is produced by applying positive active substance onto the both surfaces of the electricity collection substrate. As the electricity collection substrate, a metal foil such as an aluminum foil or a titanium foil, etc., which is good in corrosion resistance against positive electrochemical reaction, is used, but other than foils, punching metal or mesh may be used. In addition, as the positive active substance, a lithium transition metal compound oxide such as lithium manganese oxide ($LiMn_2O_4$), lithium cobalt oxide ($LiCoO_2$), lithium nickel oxide ($LiNiO_2$) are suitably used, and preferably ~~the~~ carbon powder such as acetylene black and the like are added to these as conduction assistant agent.

Page 32, lines 3 – 9:

VERSION OF PARAGRAPHS WITH MARKINGS TO SHOW CHANGES MADE

For assembly of the battery, at first, conductivity between the terminals to extract currents to outside and the electrode leads 5 and 6 is secured while the produced electrode body 1 is inserted into the battery case and is held in a stable position. Thereafter, after they are ~~dipped by~~ filled with the nonaqueous electrolyte solution, the battery case is sealed, and thus the battery is produced.

Page 32, lines 17 – 25:

As the lithium compound to be dissolved into such solvent, that is, an electrolyte, lithium fluoride complex compound such as hexafluoride lithium phosphate ($LiPF_6$), lithium ~~fluoborate~~ fluoroborate ($LiBF_4$), etc. or lithium halide such as ~~lithhium~~ lithium perchlorate ($LiClO_4$) ~~is nominated~~ can be used, and one or more kinds are dissolved into the above described solvent for use. In particular, it is preferable that $LiPF_6$ is used, which hardly causes oxidation decomposition and involves electrolyte solution with high conductivity.

Page 33, lines 7 – 26:

A battery related to the examples 1 to 4 and the comparative examples 1 to 4 has a wound-type electrode body fabricated with a positive electrode plate produced by coating the positive agent slurry with $LiMn_2O_4$ spinel as a positive active substance to which acetylene black as a conductive assistant agent at an external ratio of 4% by weight was added and moreover a solvent and a binder were added to the both surfaces of the aluminum foil of thickness 20 μm to make thickness of approximately 100 μm respectively and a negative electrode plate produced by coating ~~the~~ carbon powder as a negative active substance to the both surfaces of the copper foil of thickness 10 μm to make thickness of approximately 80 μm respectively in addition to the similar method hereof, and after it is contained in a battery case of ~~the~~ outer diameter of 50 mmϕ, nonaqueous electrolyte solution in which $LiPF_6$ as an electrolyte was dissolved into the

VERSION OF PARAGRAPHS WITH MARKINGS TO SHOW CHANGES MADE

equal volume mixture solvent of EC and DEC at concentration of 1 mol/l was filled ~~in~~. Incidentally, an Al pipe was used as the winding core, and ethylene propylene rubber with thickness of 1 mm was used as packing for production.

VERSION OF CLAIMS WITH MARKINGS TO SHOW CHANGES MADE

2. (Amended) The lithium secondary battery according to claim ~~1~~6, wherein a center axis of said winding core overlaps ~~the~~ a center axis of said battery case.

3. (Amended) The lithium secondary battery according to claim ~~1~~6, wherein said external terminals are made to comprise a center hollow portion so that this center hollow portion functions as a pressure release path of said pressure release hole.

5. (Amended) The lithium secondary battery according to claim ~~4~~6, wherein said winding core has thickness of not less than 0.8 mm.

6. (Amended) ~~The~~ A lithium secondary battery ~~according to claim 4,~~ comprising:

an internal electrode body formed by winding a positive electrode and a negative electrode on an outer peripheral wall of a hollow cylindrical winding core;

a cylindrical battery case containing the internal electrode body inside with both ends thereof being open;

nonqueous electrolyte solution contained in said case and contacting said positive electrode and said negative electrode; and

electrode caps having battery caps, internal terminals, and external terminals which seal said internal electrode body at both open ends of the battery case,

wherein at least one of the electrode caps has a pressure release hole in a position corresponding with the center axis of the winding core,

wherein the capacity (C) of said internal electrode body is not less than 2 Ah, and said pressure release hole's sectional area (S_1) as well as said winding core's center hollow portion's sectional area (S_2) are larger than 0.3 (cm^2),

and wherein the values given by dividing said pressure release hole's sectional area (S_1) and said winding core's center hollow portion's sectional area (S_2) by said internal electrode body's battery capacity (C) respectively (S_1/C and S_2/C) are both larger than 0.02 (cm^2/Ah).

VERSION OF CLAIMS WITH MARKINGS TO SHOW CHANGES MADE

7. (Amended) The lithium secondary battery according to claim ~~1~~6, wherein the size of said winding core's center hollow portion's sectional area (S_2) is not less than said pressure release hole's sectional area (S_1).

8. (Amended) The lithium secondary battery according to claim ~~1~~6, wherein said winding core is made of aluminum or an aluminum alloy.

9. (Amended) A lithium secondary battery comprising:

an internal electrode formed by winding a positive electrode and a negative electrode on an outer ~~periphery~~ peripheral wall of a hollow cylindrical winding core~~ and dipped into nonaqueous electrolyte solution~~;

a cylindrical battery case containing the internal electrode body inside with both ends thereof being open;

nonqueous electrolyte solution contained in said case and contacting said positive electrode and said negative electrode; and

electrode caps having battery caps, internal terminals, and external terminals, said battery caps sealing said internal electrode body at both open ends of the battery case, at least one of ~~which has~~ said battery caps having a pressure release hole ~~and which seal said internal electrode body at the both open ends of the battery case~~in a position corresponding with a center axis of said winding core,

wherein a pressure release valve is disposed on ~~the~~ an internal ~~periphery~~ peripheral wall of said pressure release hole or at the end of said pressure release hole ~~with the~~, said pressure release valve comprising an elastic body, a metal foil and a spacer, said elastic body and ~~the~~ said metal foil being brought into pressure contact with ~~a~~ said spacer to seal said battery case.

10. (Amended) The lithium secondary battery according to claim 9, wherein said metal foil is formed so as to have ~~the~~ a surface pressure of not less than 980 kPa.

VERSION OF CLAIMS WITH MARKINGS TO SHOW CHANGES MADE

12. (Amended) The lithium secondary battery according to claim 9, wherein said spacer is a ring member or a ring member having stopper structure in order that ~~the~~ stress ~~not~~ of less than a constant amount will ~~not~~ be applied to said elastic body.

13. (Amended) The lithium secondary battery according to claim 9, wherein said metal foil is made of Al, Cu~~,~~ or Ni, ~~or alloys containing them respectively that is~~ said metal foil being coated by ~~the~~ fluoride resin.

14. (Amended) The lithium secondary battery according to claim 9, wherein ~~the~~ stress applied to said elastic body is not less than 980 kPa and not more than ~~the~~ a force at which ~~amount to cause~~ said ~~that~~ elastic body ~~to maintain~~ maintains elasticity ~~maintenance percentage~~ of not less than 95%.

18. (Amended) The lithium secondary battery according to claim 1, wherein said pressure release hole is ~~commonly~~ used as the electrolyte solution inlet.

19. (Amended) A lithium secondary battery comprising:

an internal electrode formed by winding a positive electrode and a negative electrode on an outer ~~periphery~~ peripheral wall of a hollow cylindrical winding core ~~and dipped into nonaqueous electrolyte solution~~;

a cylindrical battery case containing the internal electrode body inside with both ends thereof being open;

nonqueous electrolyte solution contained in said case and contacting said positive electrode and said negative electrode; and

electrode caps which seal said internal electrode body at ~~the~~ both open ends of the battery case, ~~wherein:~~

said electrode caps ~~are formed in approximately rotary symmetry~~ being substantially rotationally symmetrical around the center axis of said battery case ~~being a center~~,

VERSION OF CLAIMS WITH MARKINGS TO SHOW CHANGES MADE

wherein at least one of the electrode caps has a pressure release hole, and said pressure release hole has a sectional area (S_1) which is larger than 0.3 cm^2, and said winding core has a center hollow portion having a sectional area (S_2) which is larger than 0.3 cm^2, and wherein the capacity (C) of said internal electrode body is not less than 2 Ah.

28. (Amended) A method of manufacturing a lithium secondary battery, which comprises:

preparing ~~a~~ plate-like ~~member~~ members functioning as ~~a cap~~ caps after production, ~~an~~ elastic ~~body~~bodies, ~~a~~ metal ~~foil~~ foils and ~~a spacer~~spacers which are processed in advance to a predetermined size;

disposing each said elastic body and each said metal foil in ~~a~~ predetermined ~~position~~positions;

combining ~~them~~ each said elastic body and each said metal foil with a said spacer to form a pressure release hole unit;

fitting each said pressure release hole unit into a said plate-like member to produce electrode caps;

~~containing~~ positioning an internal electrode body in a battery case; and

sealing the battery case with said electrode caps.

VERSION OF ABSTRACT WITH MARKINGS TO SHOW CHANGES MADE

Abstract of the Disclosure

A lithium secondary battery has an internal electrode body formed by winding a positive electrode and a negative electrode on an outer ~~periphery~~ peripheral wall of a hollow winding core and ~~dipped into~~filled with nonaqueous electrolyte solution, a cylindrical battery case containing this internal electrode body 1 inside with its both ends being open, and ~~has~~ electrode caps which each have a battery ~~caps~~cap, an internal ~~terminals~~terminal, and an external ~~terminals~~terminal, ~~and seal~~ the internal electrode body being sealed by the electrode caps at ~~the~~ both open ends of the battery case. At least one of the electrode caps has a pressure release hole in a position corresponding with the center axis of the winding core.